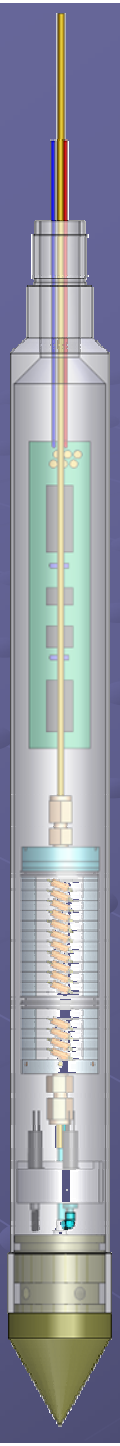
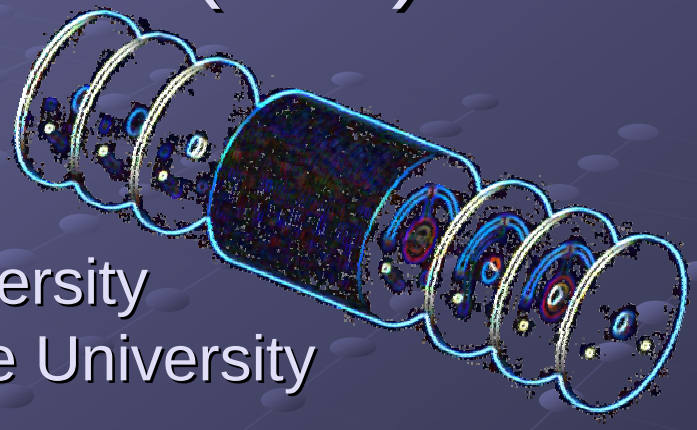
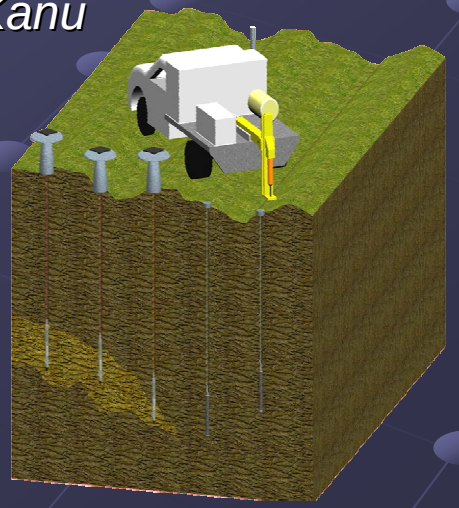


Boise State University Ion Mobility Spectrometer (IMS) Sensor Project



Molly M. Gribb, Boise State University
Herbert H. Hill, Washington State University

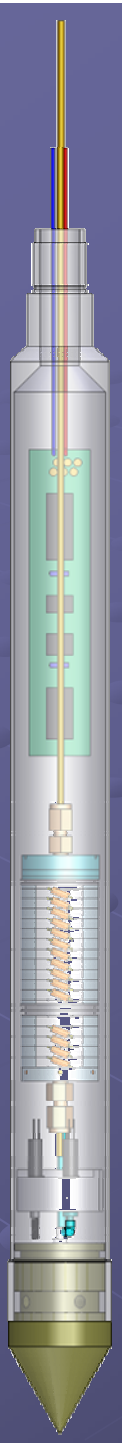
Co-PIs: Jake Baker, Sin Ming Loo, Amy Moll
Research Staff: Robert Walters, Jerome Imonigie, Abu Kanu (WSU), Don Plumlee, Dick Sevier
Students: Kevin Ryan, Jon Cole, Suren Eruvuru, Robert Youngberg, Jordi Figueras, Brian Jaques, Hope Weston
Industrial partners: Frank Riskey and Layne Simmons, TenXsys (Eagle, Idaho)



EPA Contract No. X-97031102-0
John Barich, Program Manager, EPA Region 10

Where is Idaho, anyway?

(The General Libraries, The University of Texas at Austin, 2005)



Overview of the IMS Sensor Project

The goal of this project is the development of a miniature, high resolution IMS sensor system for detecting gaseous volatile organic compounds in the vadose zone.

This sensor system will allow for in-situ measurement, unattended operation, and wireless or satellite transmission of data to the user via the Internet.

Can be used individually for characterization or in arrays for long-term monitoring of contaminated sites.

IMS is Used for Rapid Analysis of

- Chemical warfare agents
- Narcotics
- Explosives
- Amino acids, peptides, etc.
- Pesticides

Explosives and Narcotics Detection

GE Ion Track
Wilmington, MA

ITEMISER

IONSCAN

Smiths Detection
Mississauga, Ont.
Canada

VaporTracer2

SABRE 4000

Gated-Grid IMS Detectors in Military Service for Chemical Warfare Defense

CAM & I-CAM
U.S. Forces, *et al.*

Manufactured by
Smiths Detection **General Dynamics**
Watford, UK **Deland, FL**

MCAD
UK Forces
Manufactured by
Smiths Detection
Watford, UK

ACADA or M-22
U.S. Forces
Manufactured by
Smiths Detection
Watford, UK

RAID-1
German Forces, *et al.*

Manufactured by
Bruker Daltronics
Leipzig, Germany

Hand-Held Ion Mobility Spectrometers
Products in Development or Off-the-Shelf

Lightweight Chemical Detector

Gated-Grid IMS
Smiths Detection
Watford, UK

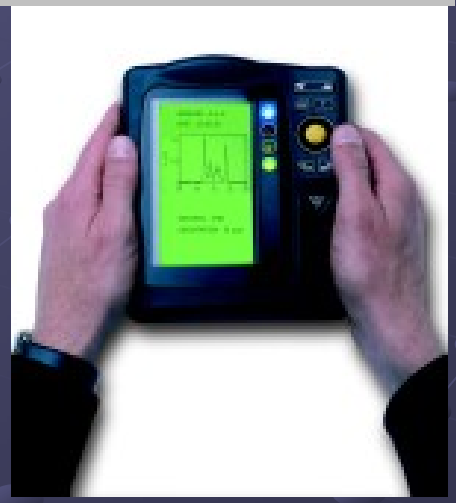
ChemPro-100

Open-Loop IMS
Environics, Oy
Mikkeli, Finland

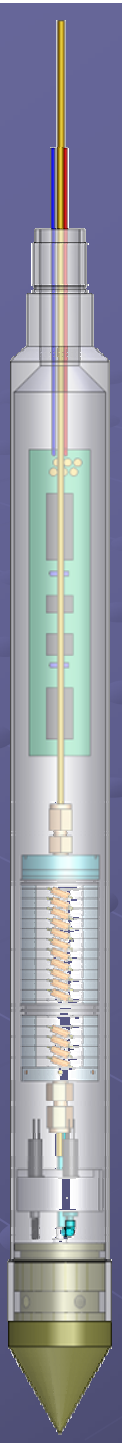
microDMx

AC-DC IMS
Sionex Corp.
Waltham, MA

μ-IMS

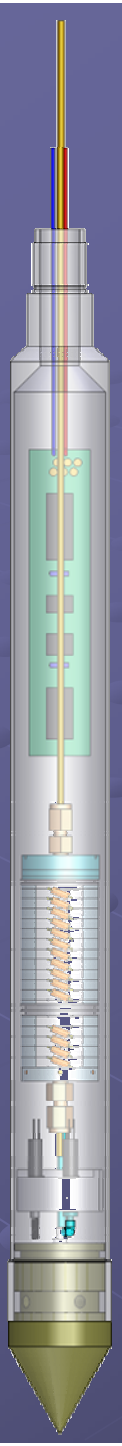


Gated-Grid IMS
G.A.S.
Gesellschaft fur Analytische Sensorsysteme
Dortmund, Germany



How an IMS works:

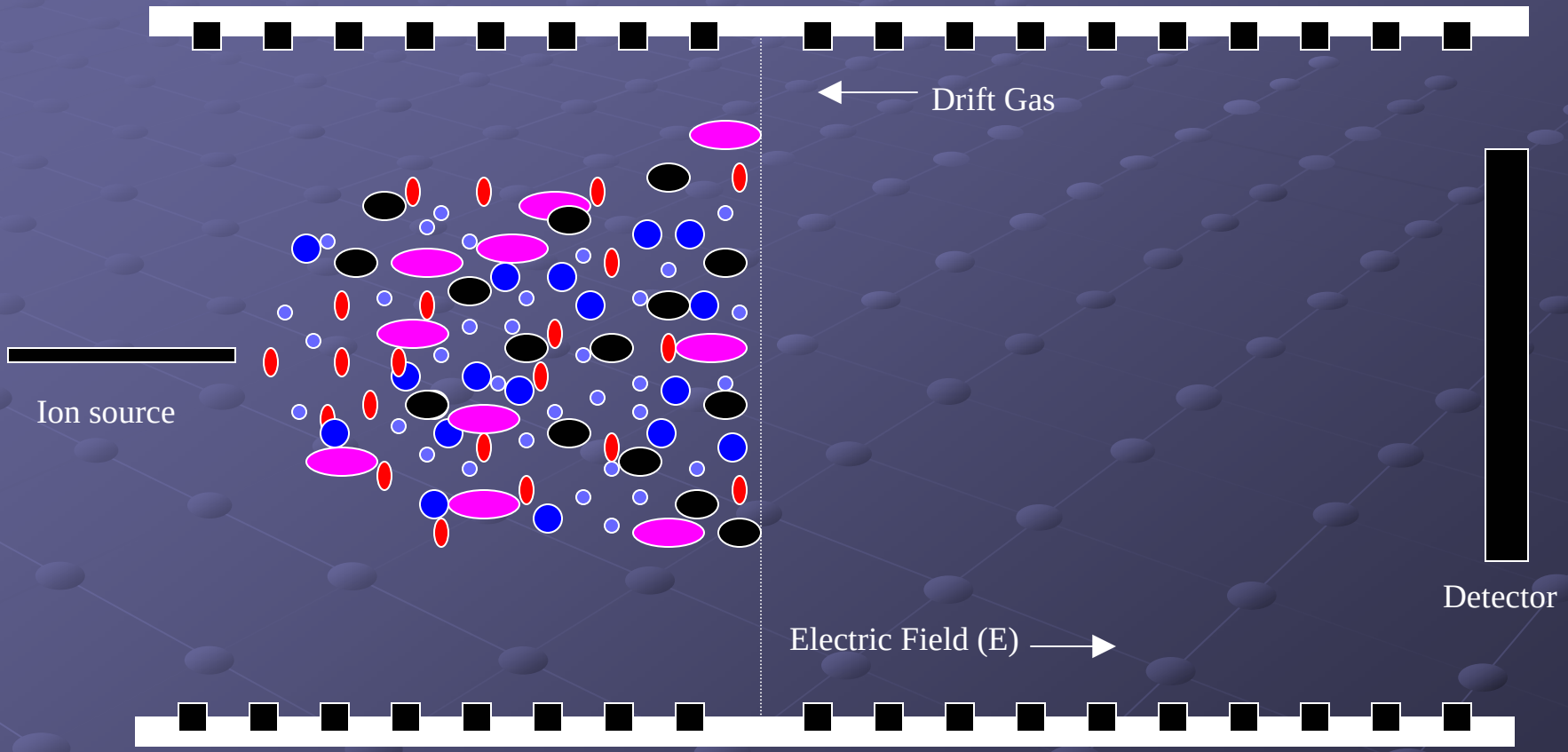
- A gaseous sample is introduced to the IMS reaction region, where it is ionized.
- The ion gate is activated to allow the ionized species into the drift tube.
- In the presence of an electric field and a counter- flowing drift gas, the ionized species travel through the drift tube toward the detector.



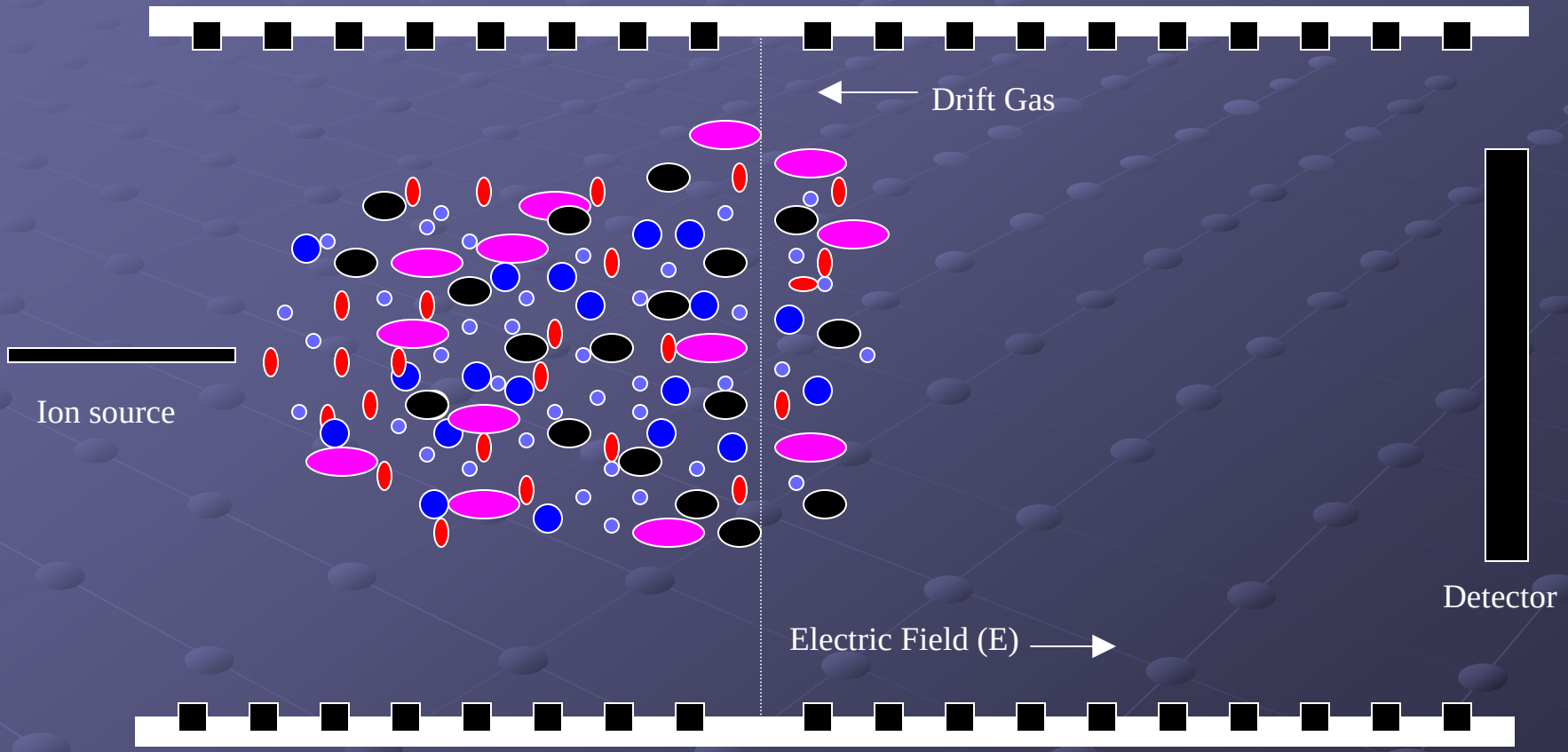
How an IMS works, cont.

- The various ionized species separate due differing collision cross-sectional areas, arriving at the detector at different times.
- As each ion discharges on the detector, a small current is generated.
- The measurement of this current over time yields a spectrum which is then used to identify and quantify the analytes in the sample.

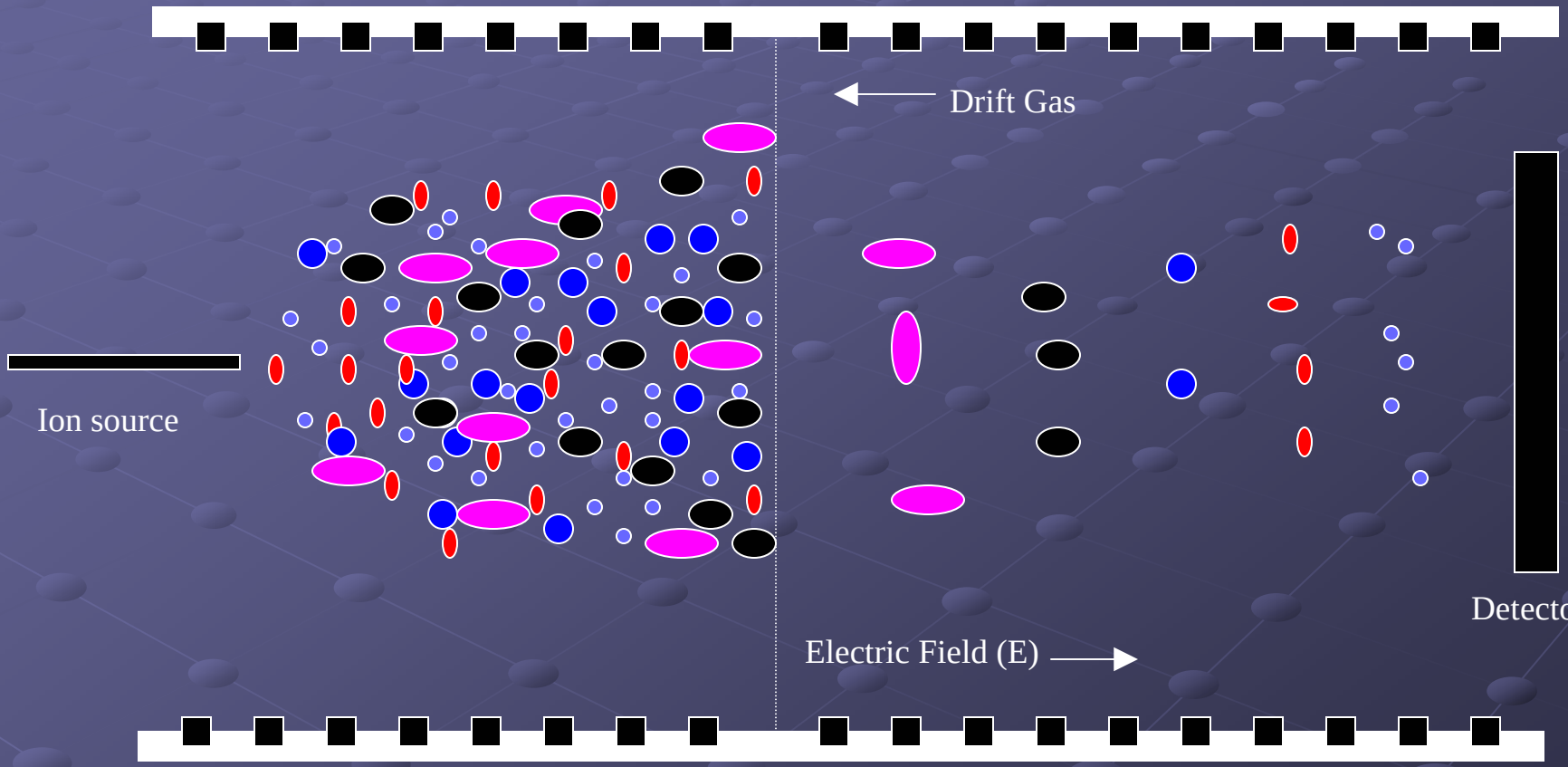
Ion Mobility Experiment



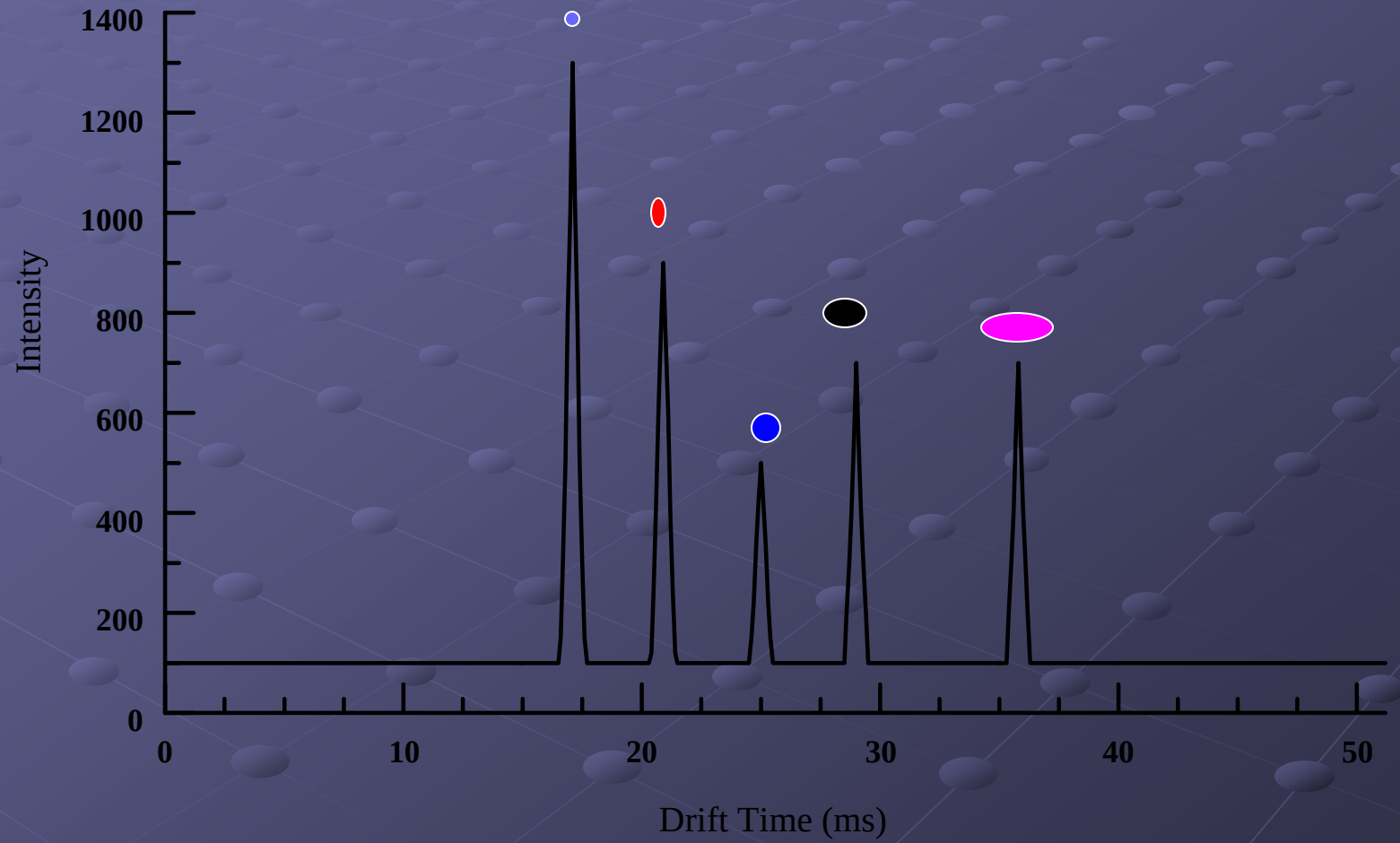
Ion Mobility Experiment



Ion Mobility Experiment



Ion Mobility Spectrum

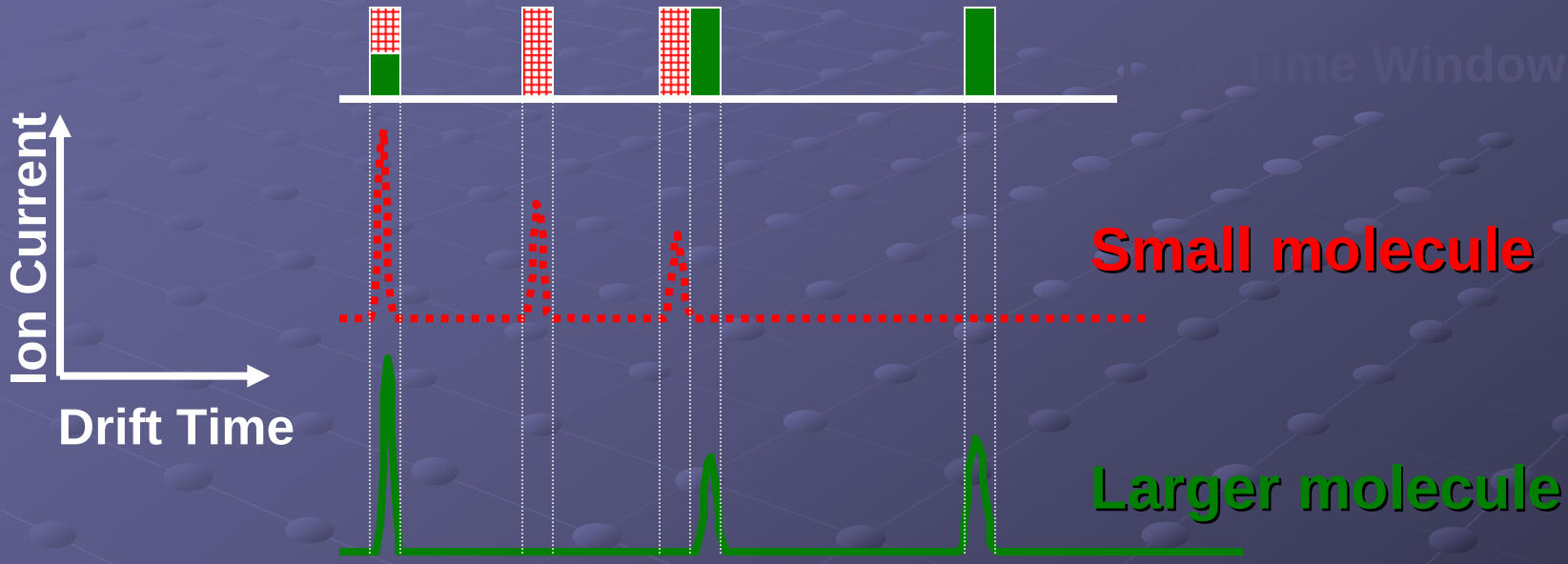


Ion Mobility Rules

$$v = KE \Rightarrow \frac{L}{t_d} = K\frac{V}{L} \Rightarrow K = \frac{L^2}{Vt_d}$$

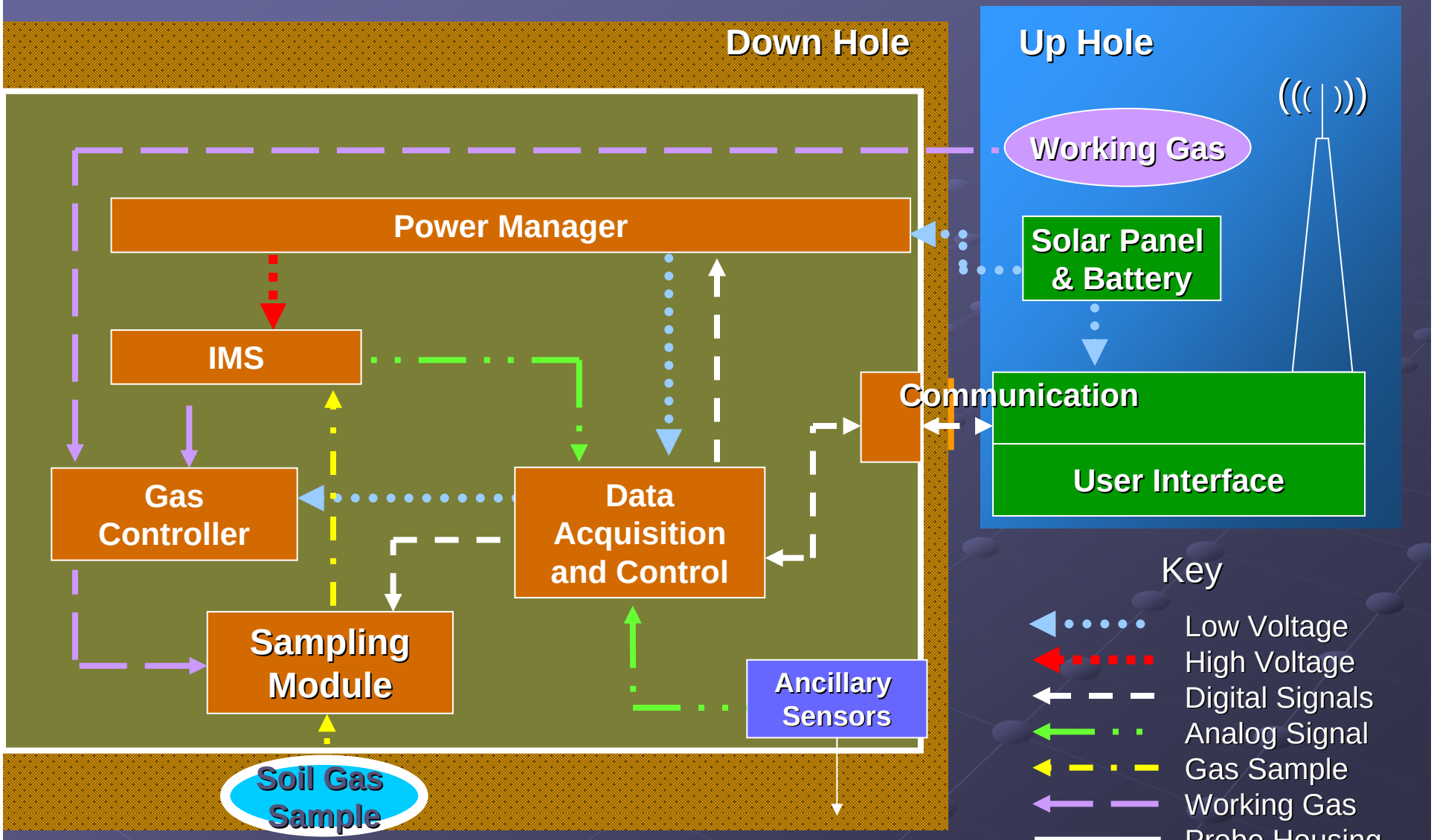
$$K_o = \frac{L^2}{Vt_d} x \frac{273}{T} x \frac{P}{760}$$

Compound Identification

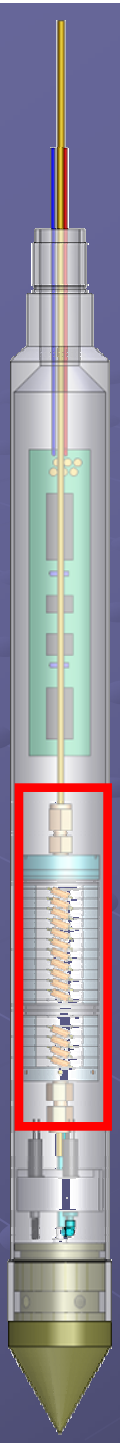


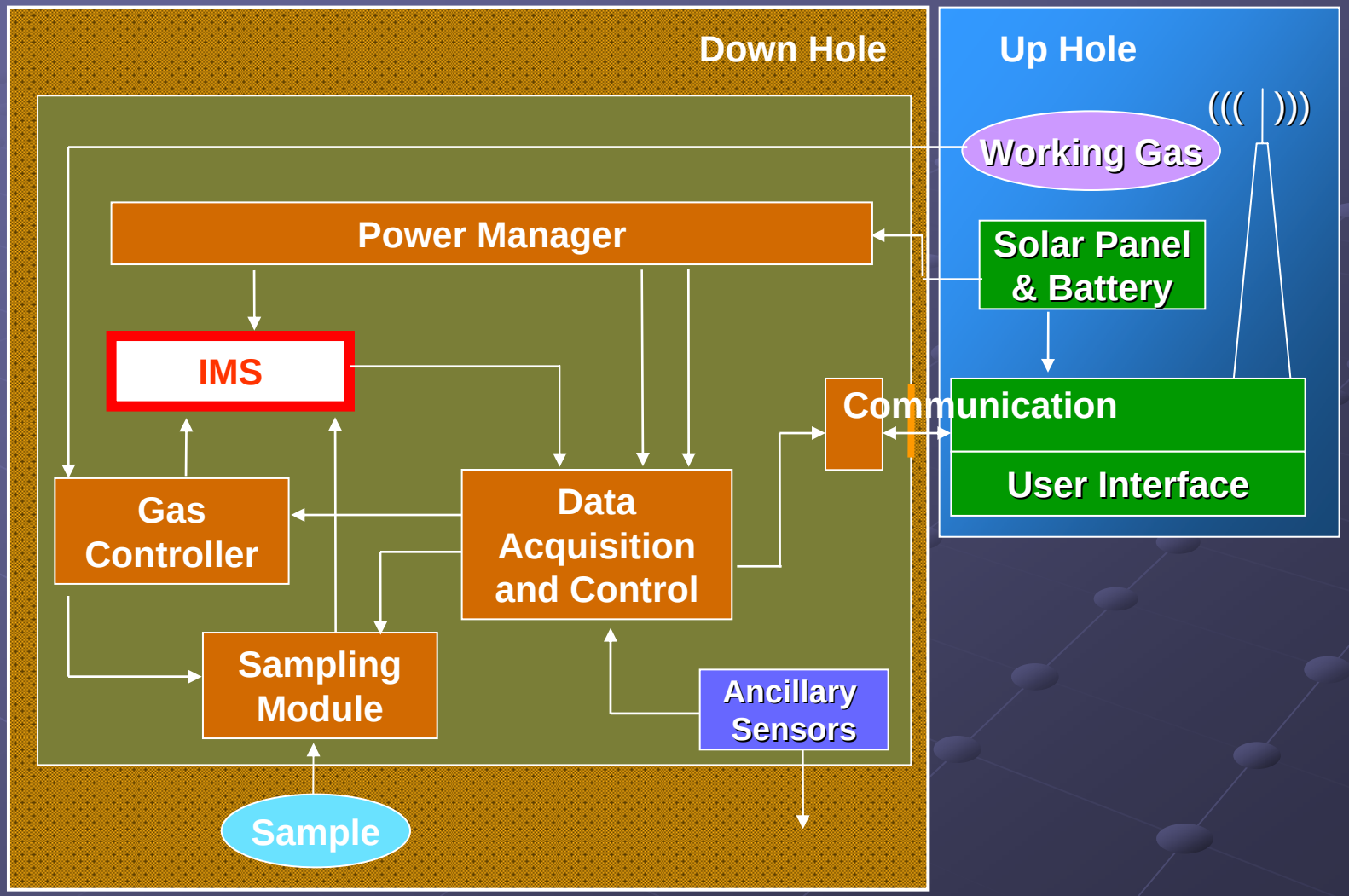
- For an Gated-Grid IMS to respond to a specific chemical, the signal must exhibit a maximum value within the appropriate drift time window(s).
- Appearance of peaks in appropriate windows provides compound identification; signal intensities in those windows provide quantification.

Block Diagram of the BSU IMS Sensor System

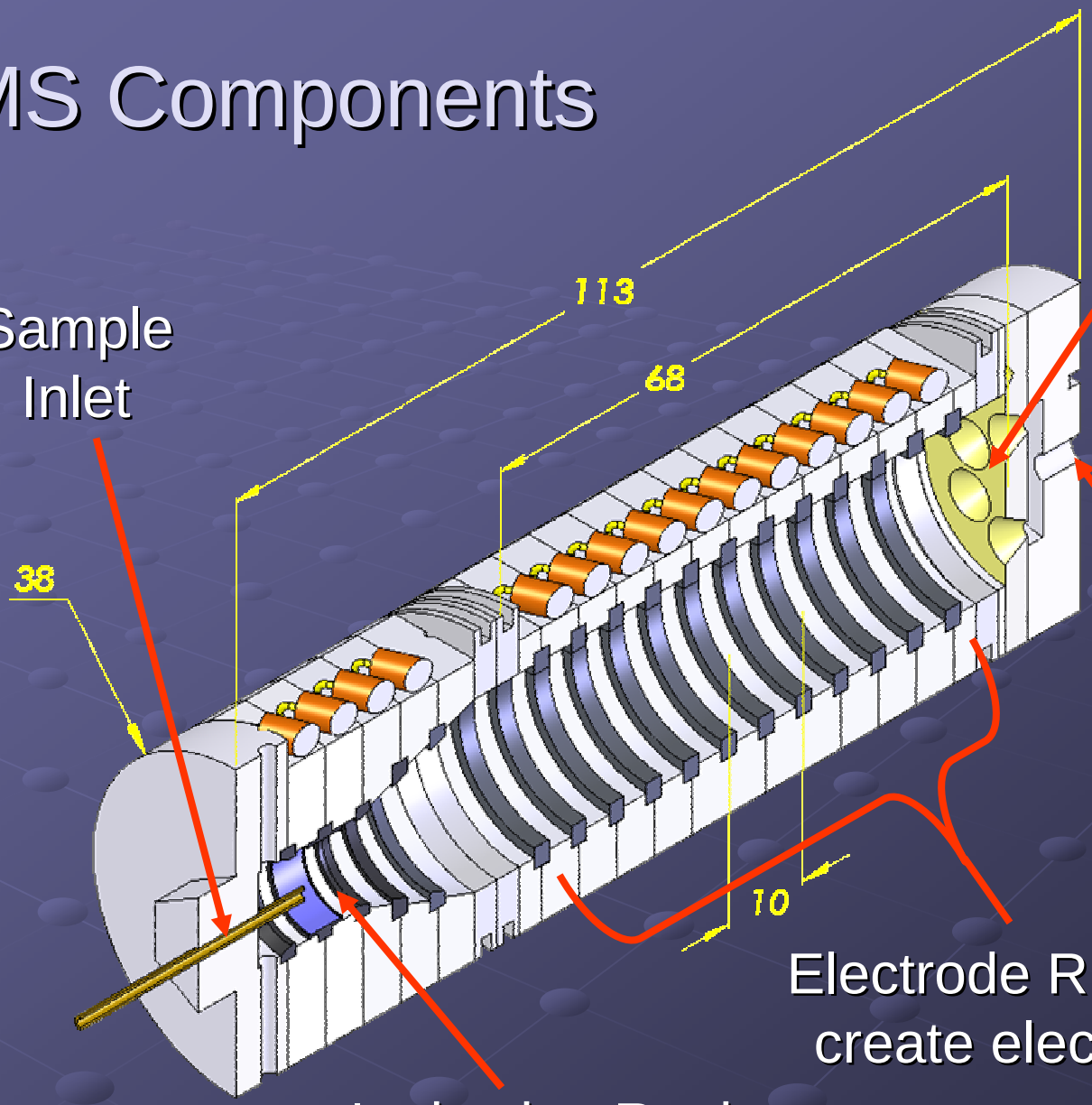


The IMS Sensor





IMS Components



Sample Inlet

Faraday Plate (Detector)

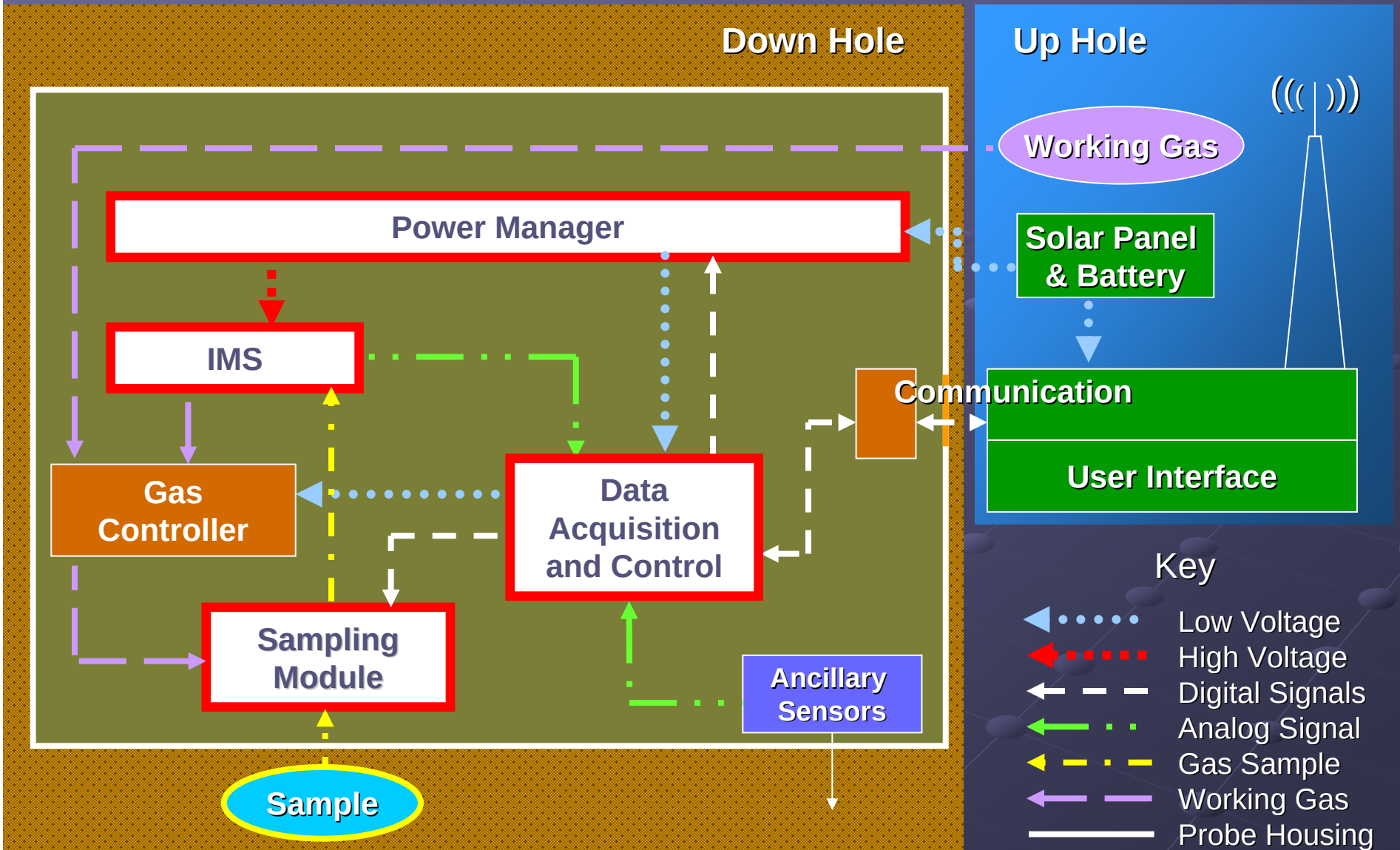
Drift Gas Inlet

Electrode Rings that create electric field

Ionization Region

Units in mm

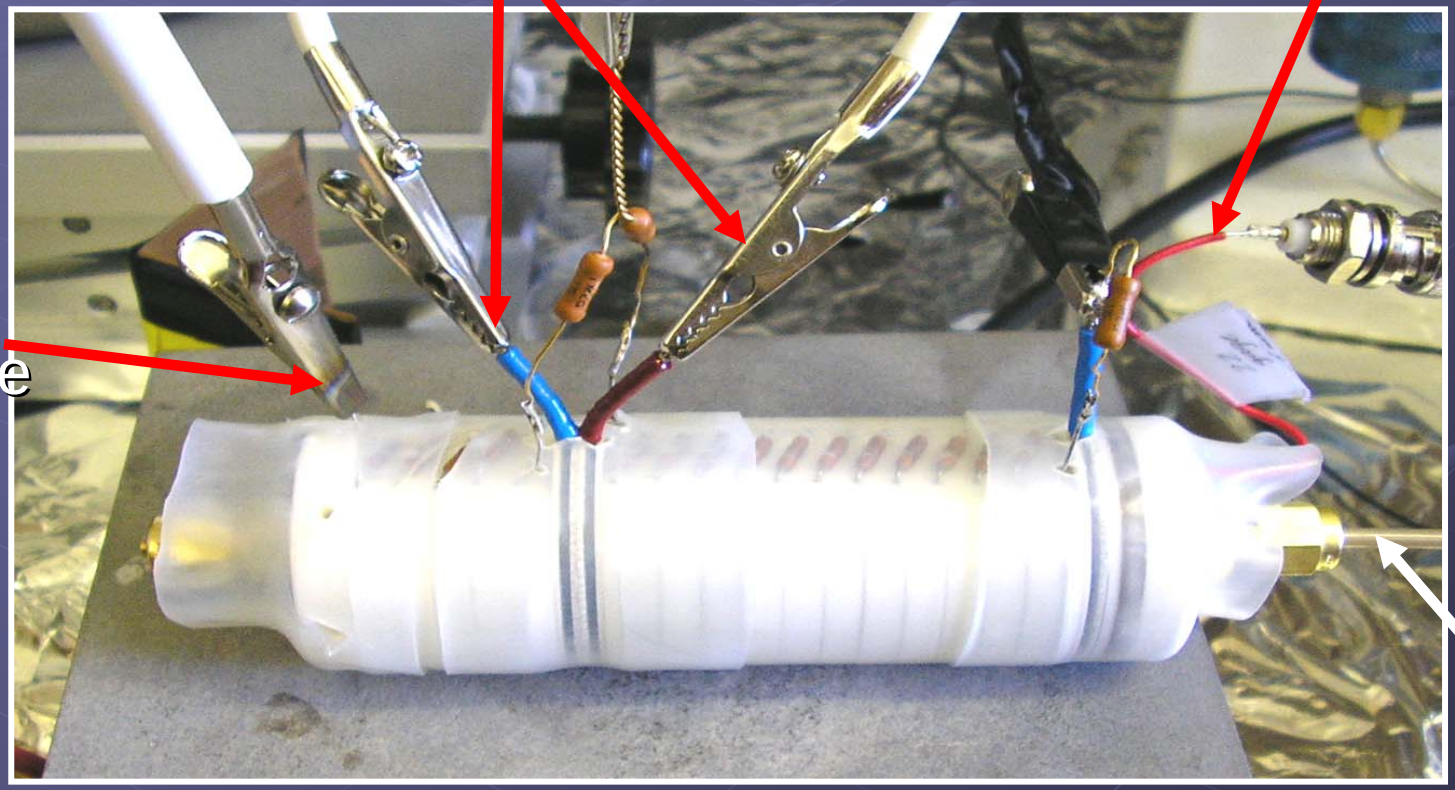
IMS Sensor System Lab Test



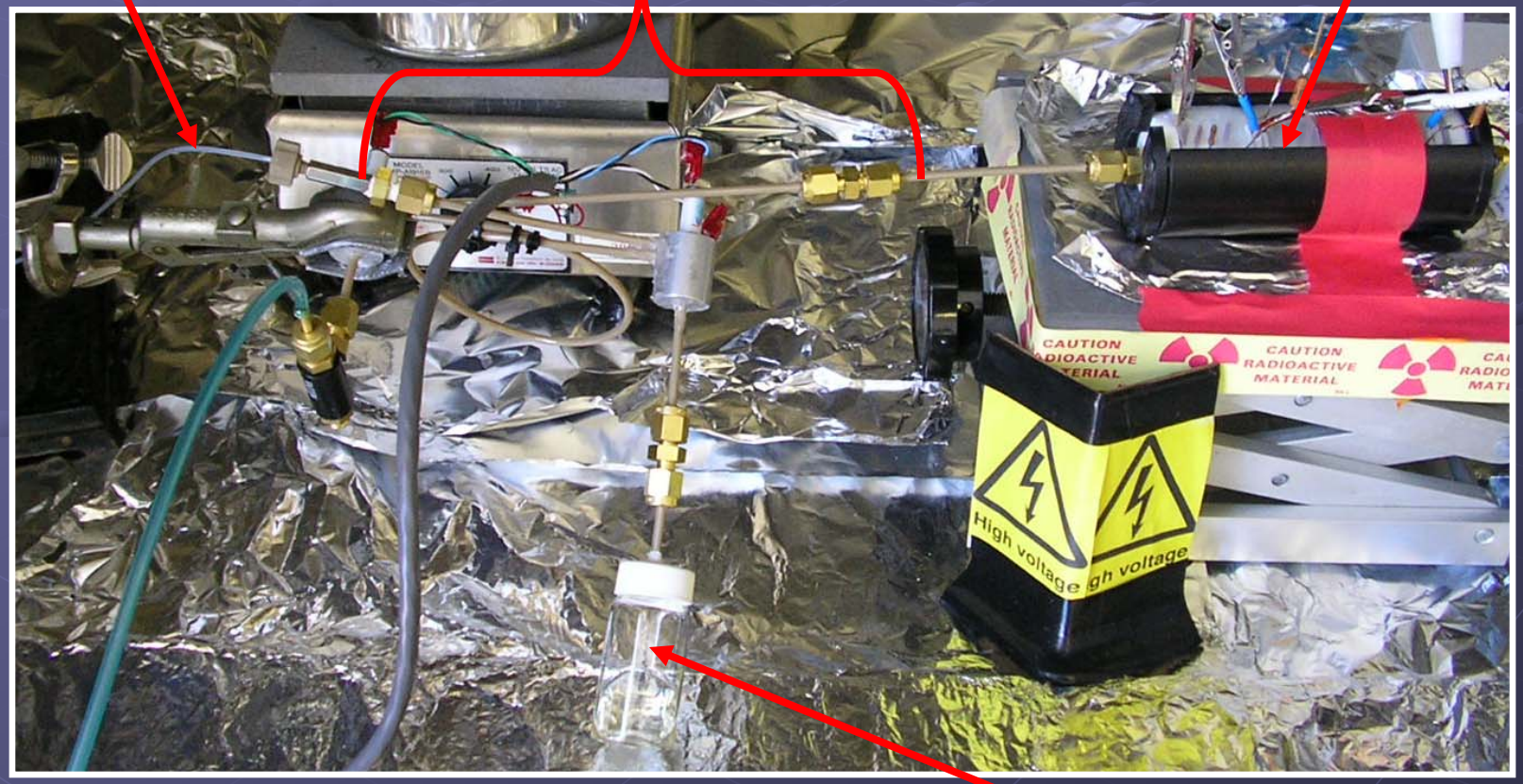
Prototype Testing Methodology

- Test Various Components
  - IMS and Sampling Module
  - Our High Voltage Power Supply vs. Lab Supply
  - Our Preamplifier vs. Lab Preamplifier
- Test System
  - IMS + Sampling Module + Data Acquisition System vs. Lab Data Acquisition System

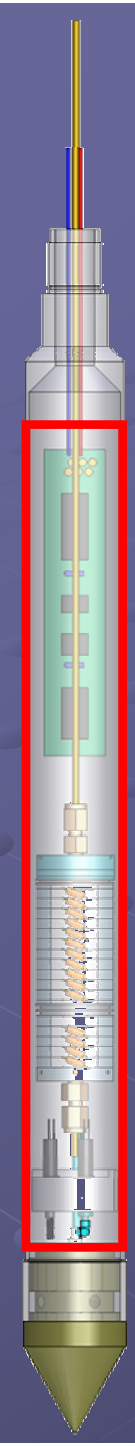
IMS Test Setup

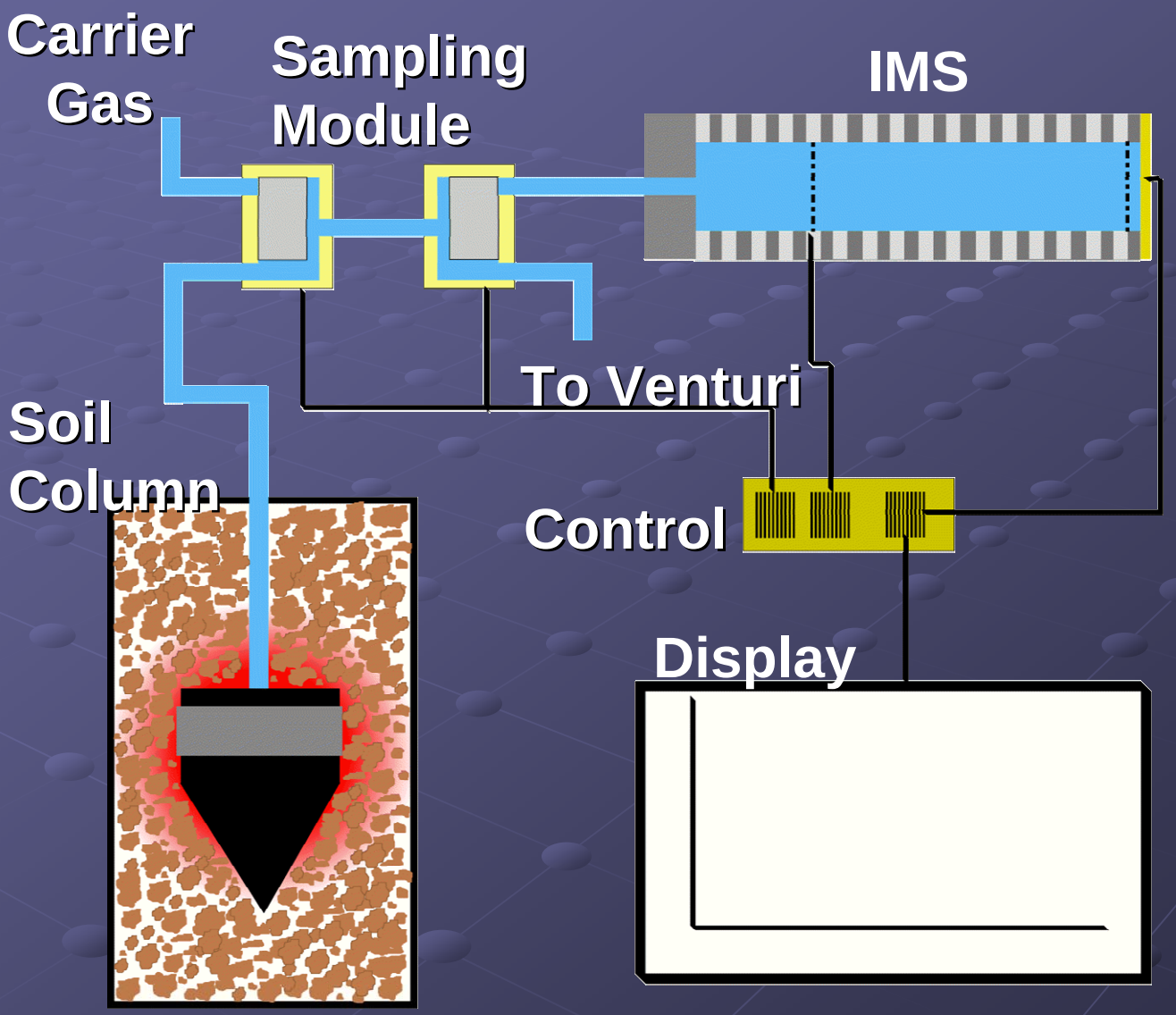


IMS + Sampling Module Testing

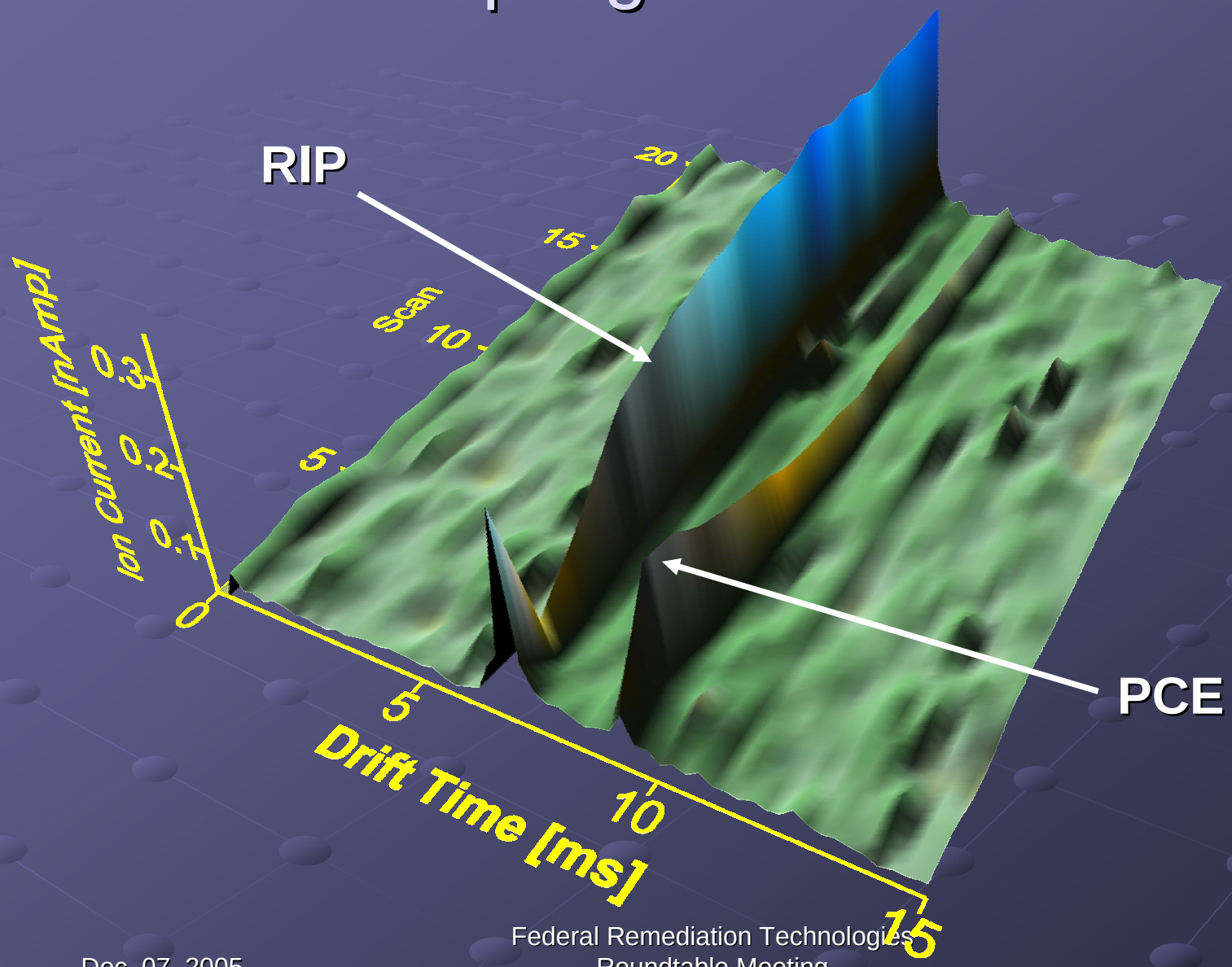


IMS Sensor Testing

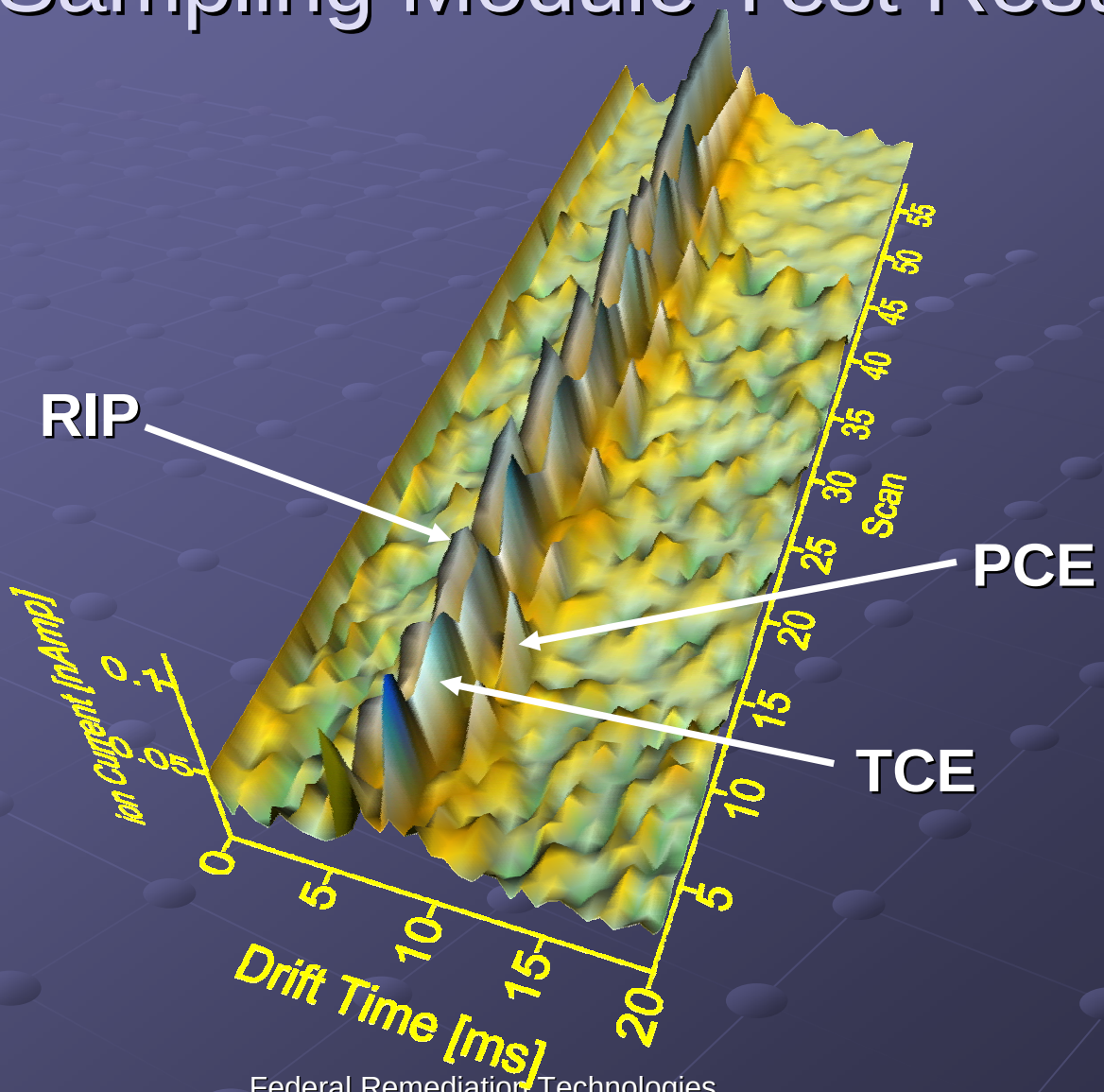




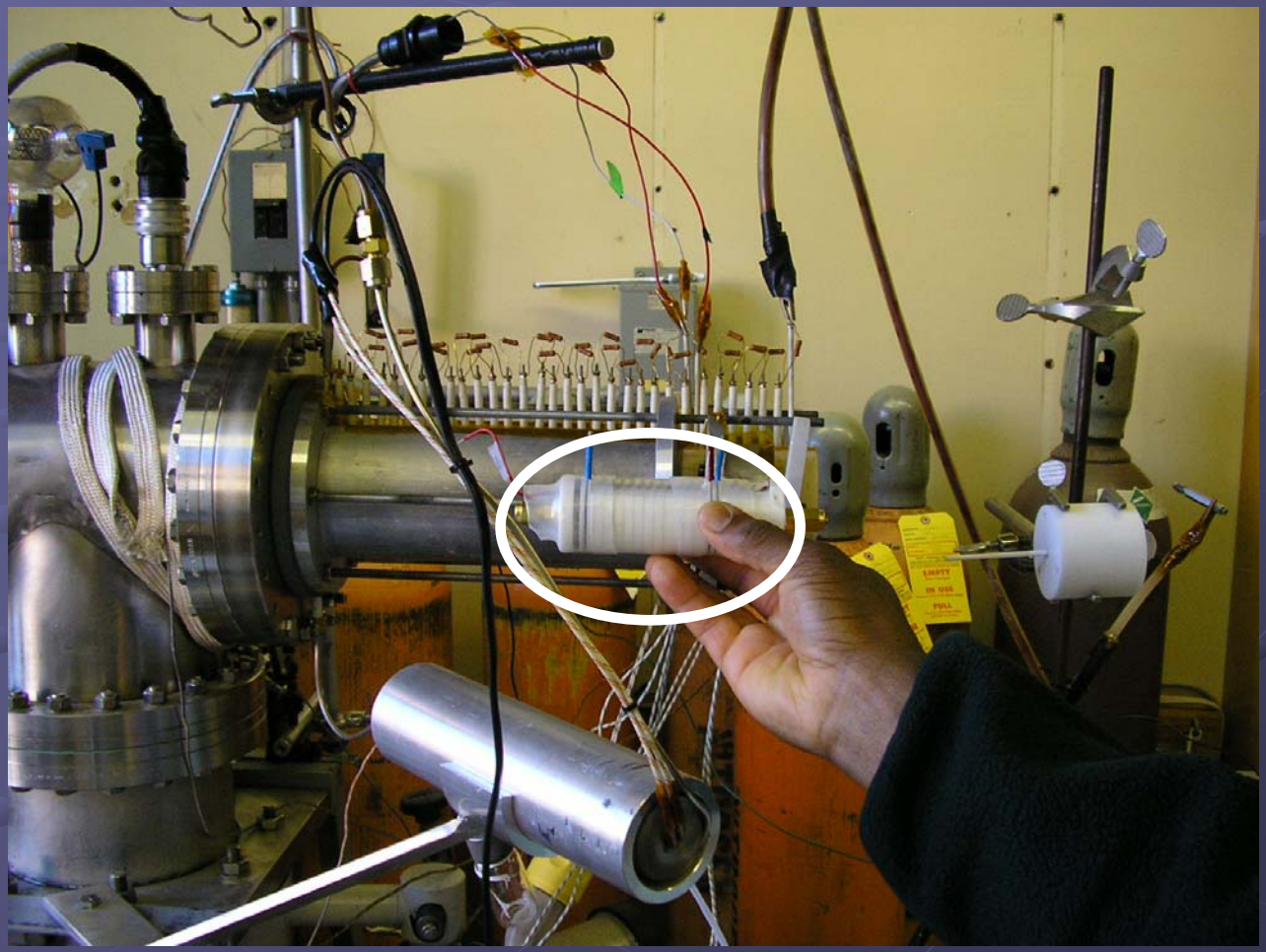
IMS + Sampling Module Test Results



IMS + Sampling Module Test Results

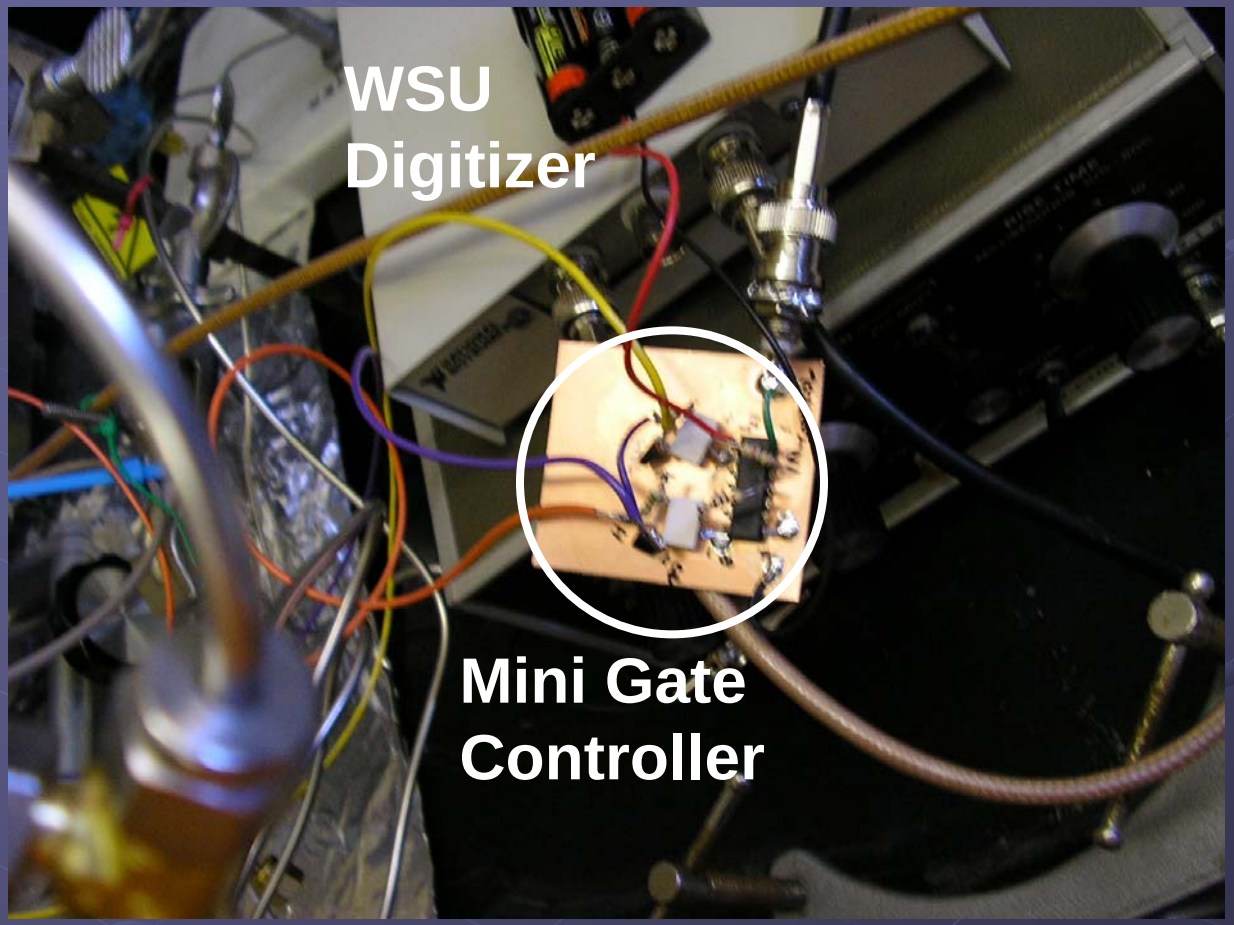


WSU Lab IMS vs. IMS Prototype

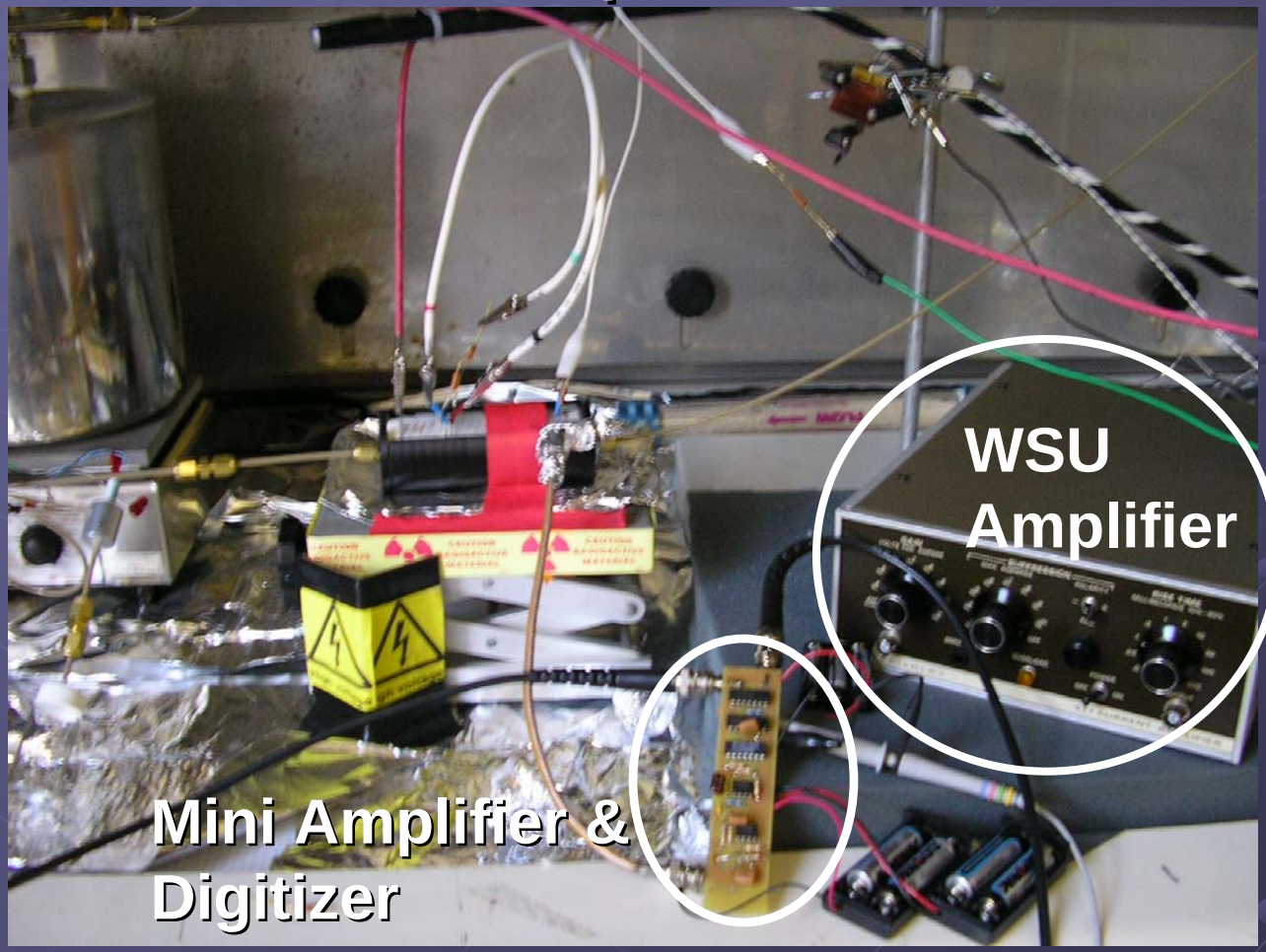


WSU Gate Controller & 4kV Supply

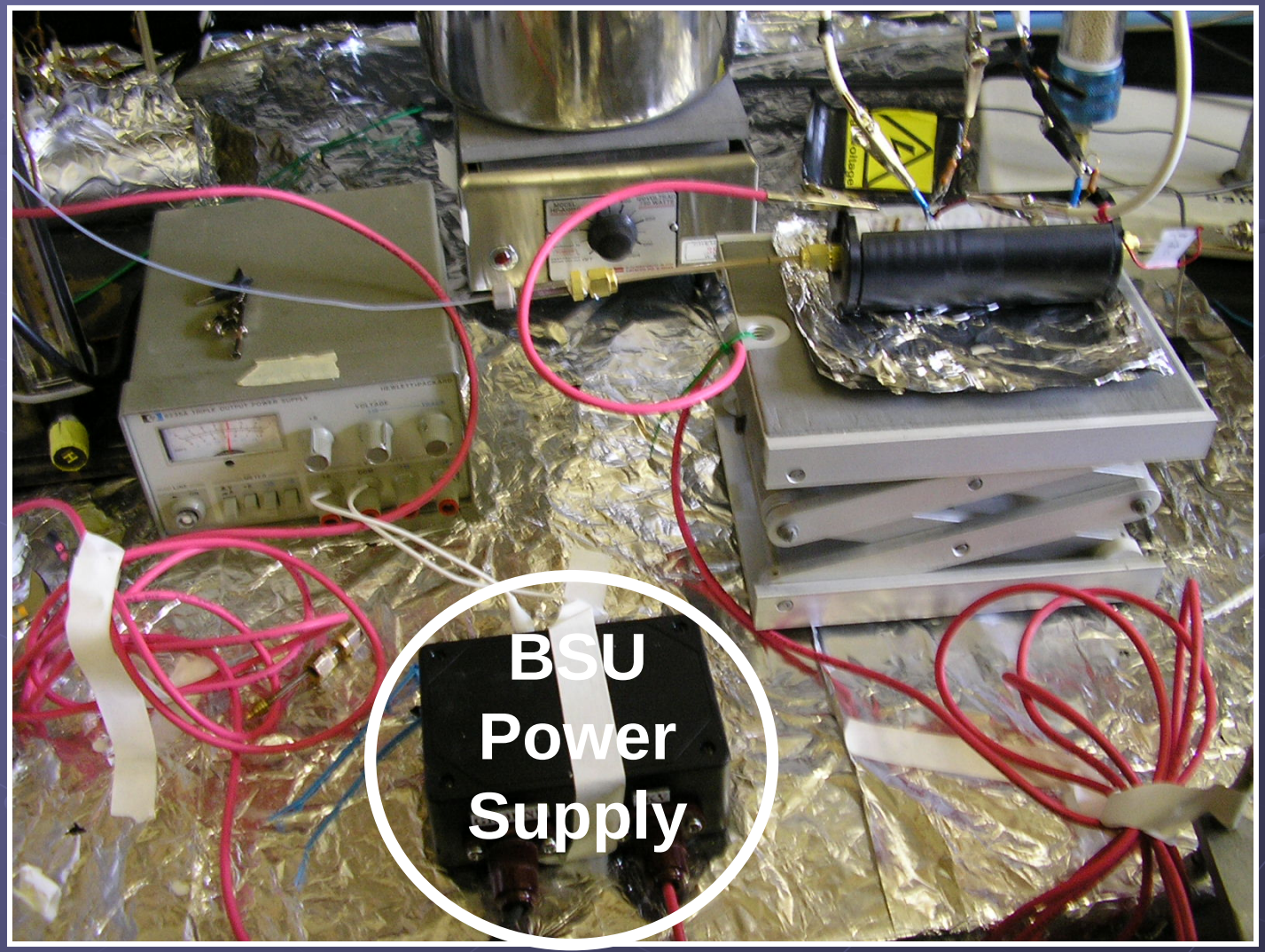
BSU Mini Gate Controller



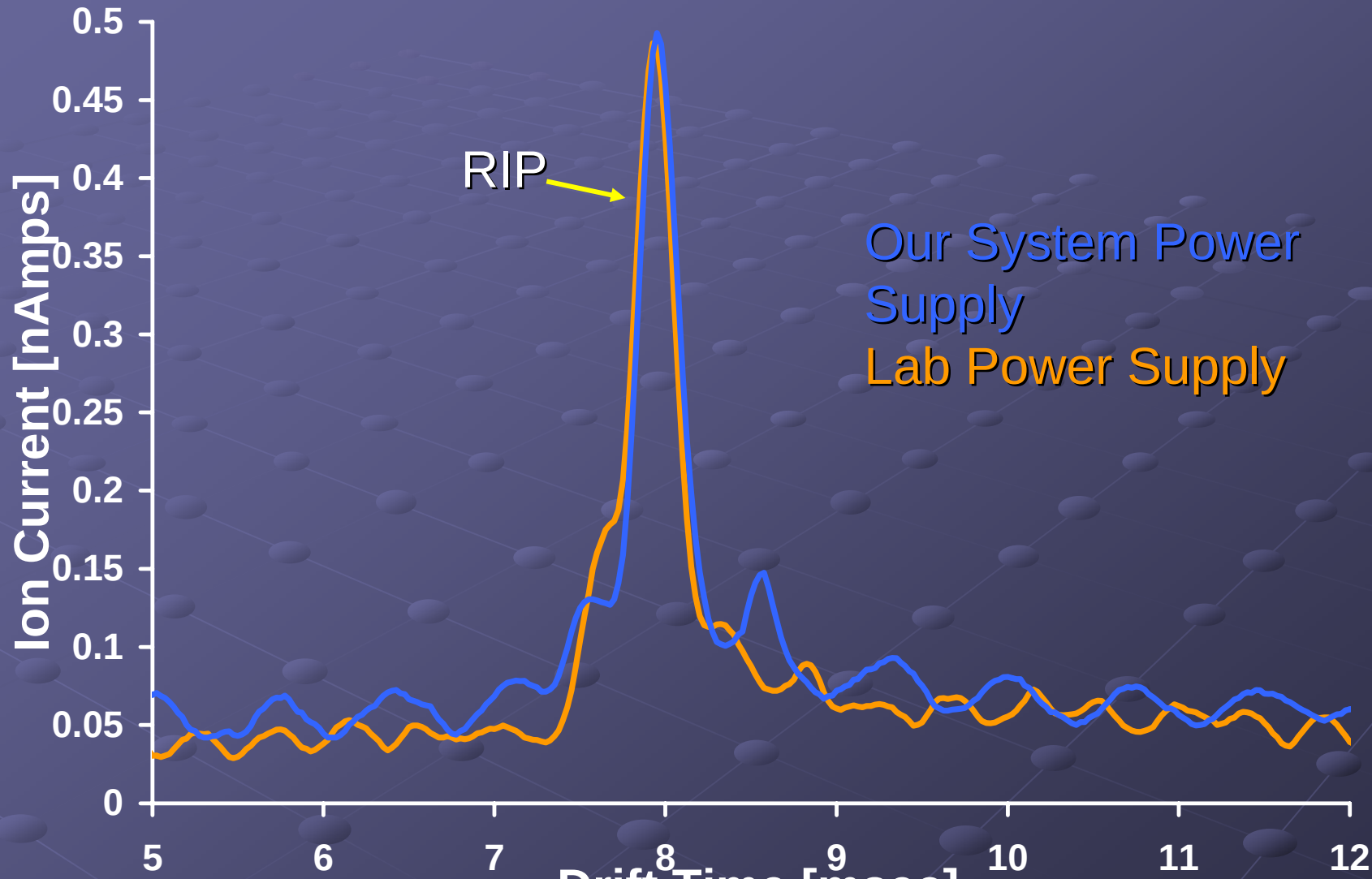
BSU Mini Amplifier/Digitizer vs WSU Amplifier



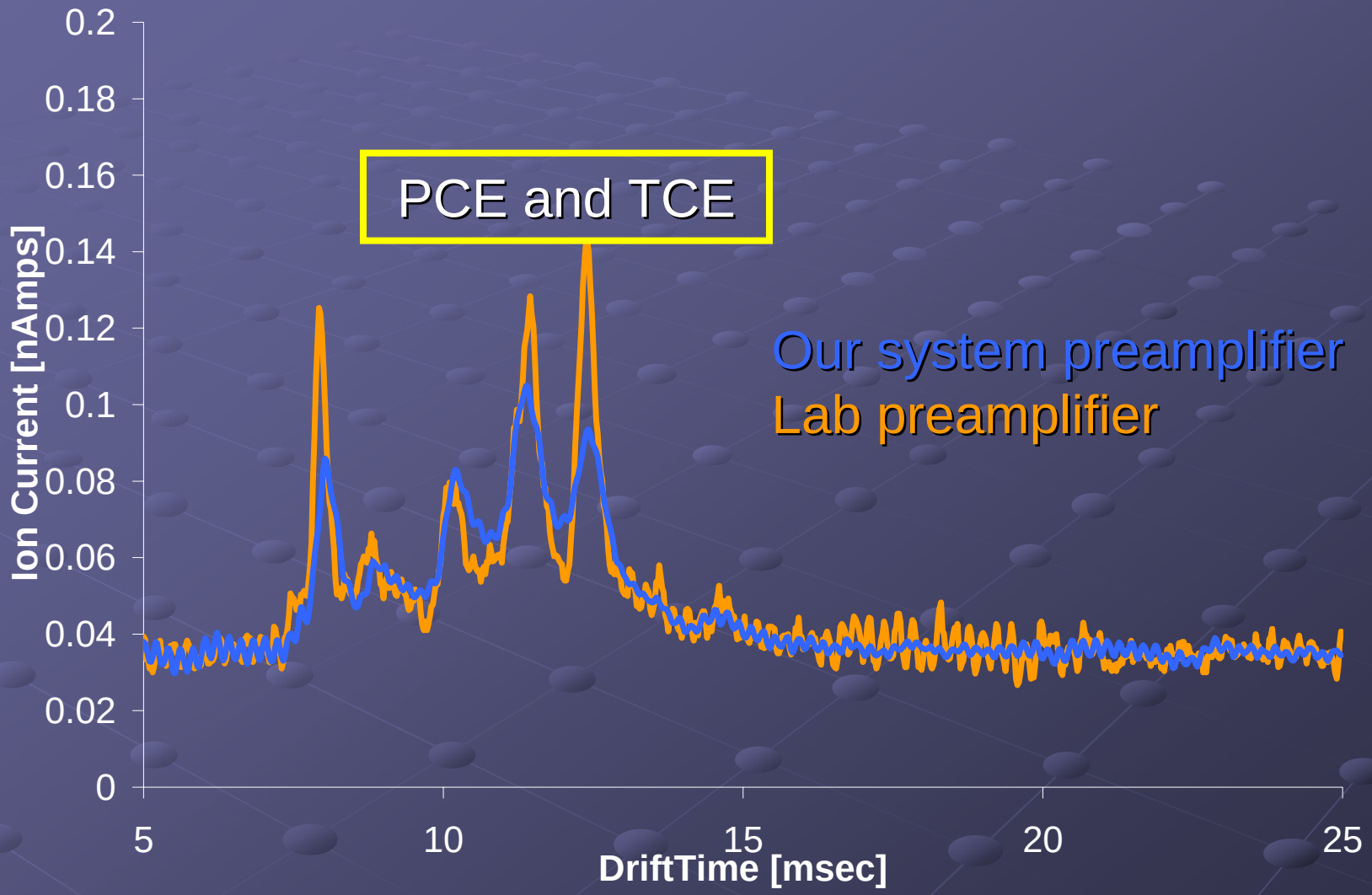
High Voltage Power Supply Test Setup



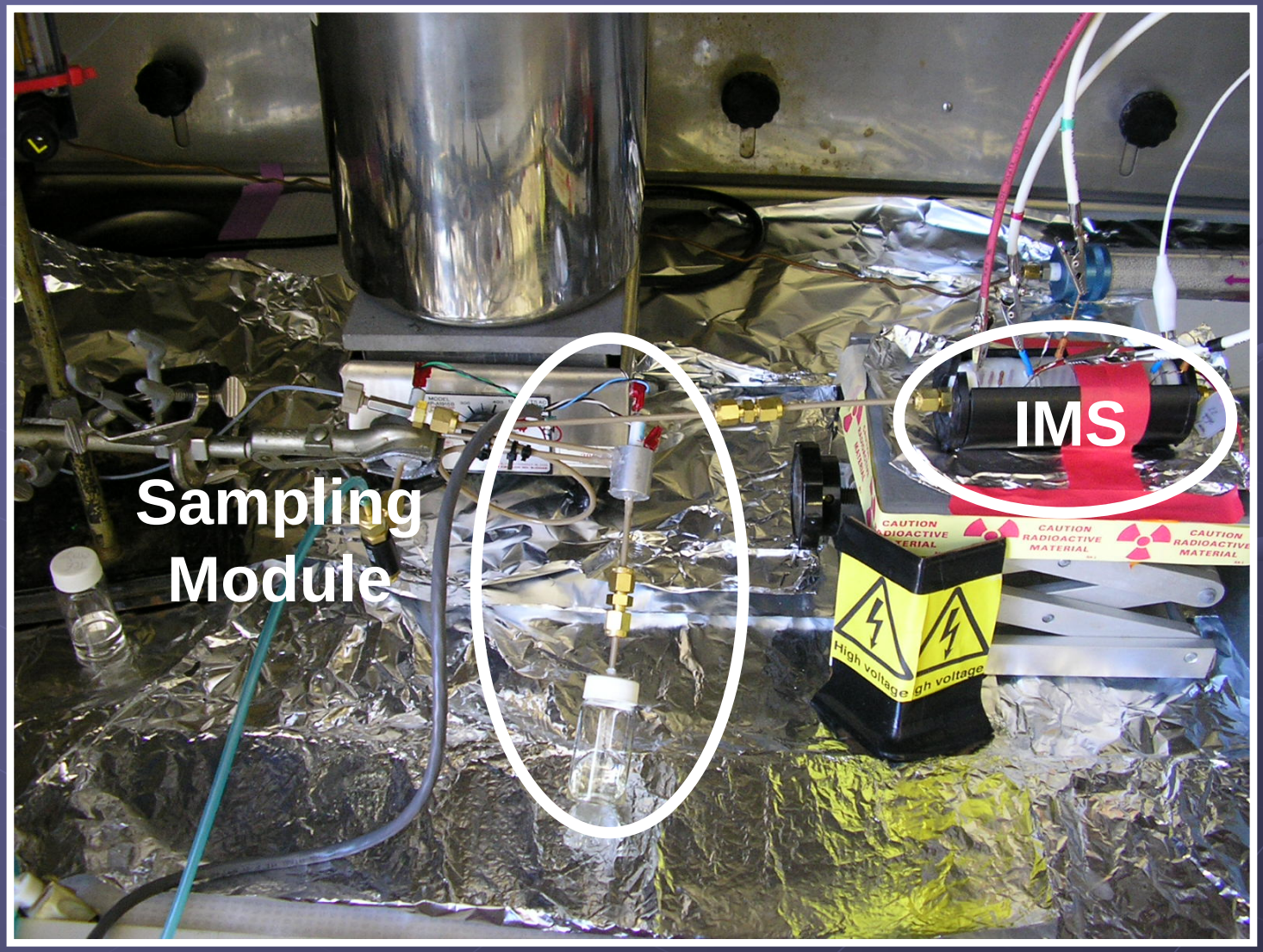
IMS + Power Supply Comparison



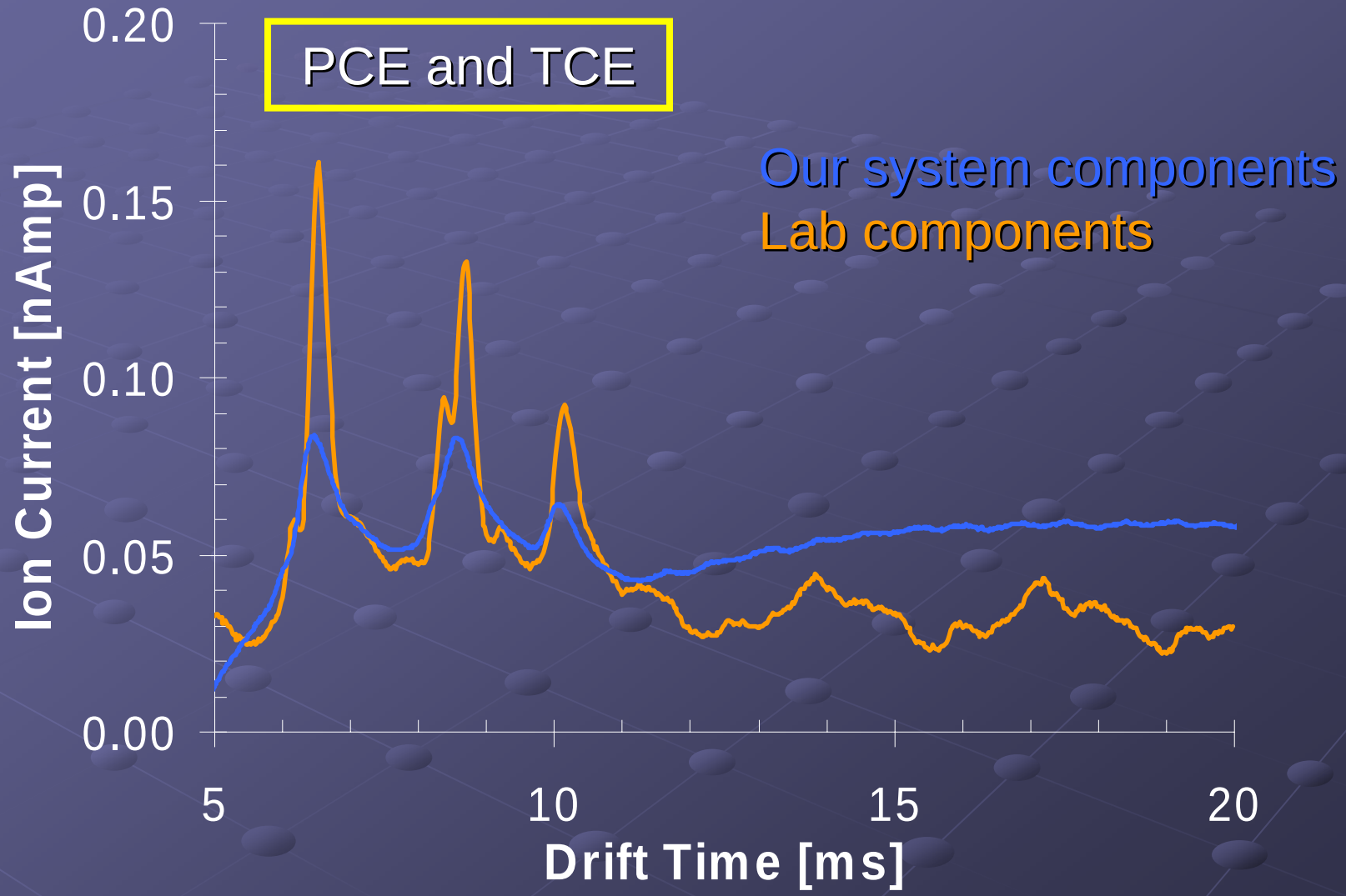
IMS + Preamplifier Comparison



End-to-End IMS Test Setup



End-to-End IMS Test Results



Summary of IMS Accomplishments

- Component Design and Test
  - ✓ IMS Prototype
  - ✓ Sampling Module
  - ✓ High Voltage Power Supply
  - ✓ Preamplifier
- System
  - ✓ End-to-End (sample to spectra)

Next Steps…

- In-ground testing of probe in Spring ’06 on local PCE plume site
- Field-testing of probe system (invitation to demo at Savannah River National Laboratory, Summer 2006) – white paper submitted last week to DOE
- Other opportunities…

Thank you for your attention.

Any questions?